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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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INTERNATIONAL BUSINESS MACHINES CORPORATION			THORNEWELL, KIMBERLY A	
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SHORTENED STATUTORY PERIOD OF RESPONSE	MAIL DATE	DELIVERY MODE
3 MONTHS	03/26/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

If NO period for reply is specified above, the maximum statutory period will apply and will expire 6 MONTHS from the mailing date of this communication.

Office Action Summary	Application No.	Applicant(s)
	10/621,472	GORDON, RONALD L.
	Examiner Kimberly Thornewell	Art Unit 2128

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --
Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) Responsive to communication(s) filed on 05 January 2007.
 2a) This action is FINAL. 2b) This action is non-final.
 3) Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) Claim(s) 1-28 is/are pending in the application.
 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
 5) Claim(s) _____ is/are allowed.
 6) Claim(s) 1-28 is/are rejected.
 7) Claim(s) _____ is/are objected to.
 8) Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) The specification is objected to by the Examiner.
 10) The drawing(s) filed on _____ is/are: a) accepted or b) objected to by the Examiner.
 Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
 Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
 11) The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 a) All b) Some * c) None of:
 1. Certified copies of the priority documents have been received.
 2. Certified copies of the priority documents have been received in Application No. _____.
 3. Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08)
Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

1. Claims 1-28 were rejected in the Office Action dated 10/6/2006. In the reply dated 1/5/2007, Applicant amended claims 1, 9, 15, and 23. Therefore all of claims 1-28 remain pending in the instant application.

Response to Arguments

2. Applicant's arguments filed 1/5/2007 have been fully considered but they are not persuasive.

Claim Rejections, 35 USC 112, Second Paragraph

3. The Examiner thanks Applicant for amending claims 9 and 23 to recite the limitation "said TCC." The limitations in claims 9 and 23 now contain sufficient antecedent basis. Accordingly, the rejection to the claims under 35 USC 112, second paragraph, is withdrawn.

Claim Rejections, 35 USC 101

4. The Examiner respectfully notes Applicant's added limitation of "using said image to improve said lithographic process" in independent claims 1 and 15. The amendment to the claims provides for a useful, concrete and tangible result of method for improving a lithographic process. Accordingly, the rejection to the claims under 35 USC 101 is withdrawn.

However, the Applicant stated that support for the amendment is provided at page 2 lines 10-21. Neither this citation, nor any portion of the Applicant's disclosure provides for using the

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image to improve the lithographic process. Consequently, new issues under 35 USC 112 are raised by the amendment. See detailed description below.

Claim Rejections, 35 USC 102

5. Applicant argued that the Socha reference fails to disclose integrating the integrand for each of a finite number of arcs to obtain a finite number of contour integrals, each corresponding to one of said finite number of arcs, wherein each of said finite number of contour integrals comprises an analytical solution. The Examiner respectfully traverses because page 4 equations 6 and 7 of Socha teach contour (line) integrals (**Socha page 4 paragraph 0068**). The TCC can be determined using a sum of the finite number of contour integrals (Socha page 4 paragraphs 65-65, equations 1-7).

Because Socha teaches each and every element of claims 1, 2, 8, 9, 11, 12, 15, 16, 21, 22, 25 and 26, the rejection of the claims under 35 USC 102(e) is currently maintained.

Claim Rejections, 35 USC 103

6. Regarding claims 3 and 17,

Applicant argued that Kintner fails to overcome the deficiencies of Socha, in that Kintner does not teach integrating the integrand for each of a finite number of arcs to obtain a finite number of contour integrals each corresponding to one of a finite number of arcs. However, as describe in section 5 above, Socha teaches these features. Therefore the rejection of claims 3 and 17 under 35 USC 103 over Socha in view of Kintner is currently maintained.

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7. Regarding claims 13, 14, 27 and 28,

Applicant argued that Arnison fails to overcome the deficiencies of Socha, in that Arnison does not teach integrating the integrand for each of a finite number of arcs to obtain a finite number of contour integrals each corresponding to one of a finite number of arcs. However, as described in section 5 above, Socha teaches these features. Therefore the rejection of claims 3 and 17 under 35 USC 103 over Socha in view of Arnison is currently maintained.

Misprint in US Patent Application Publication no. 2005/0015233

8. The Examiner thanks the Applicant for pointing out the misprint in the US Patent Application No. 2005/0015233 at equation (41) and at the first line of paragraph [0119]. At the time of allowance of the application, this issue will be corrected.

Claim Rejections - 35 USC § 112

9. The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

10. Claims 1-28 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention. Independent claims 1 and 15 contain the limitation of using a simulated image to improve a lithographic process. This limitation was not sufficiently described in the disclosure as to enable one of ordinary skill in the

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art to make and/or use the invention. What are the steps of the lithographic process? What are the steps taken in using the image? How it used to improve a lithographic process?

11. The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

12. Claims 1-28 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claims 1 and 15 contain the limitation of using an image to improve a lithographic process. How is the image used? How is the improvement performed?

13. Claims 1-28 are rejected under 35 U.S.C. 112, second paragraph, as being incomplete for omitting essential steps, such omission amounting to a gap between the steps. See MPEP § 2172.01. The omitted steps in claims 1 and 15 are the steps taken in the claimed lithographic process, and the taken to improve the lithographic process.

Claim Rejections - 35 USC § 102

14. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.



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15. Claims 1, 2, 8, 9, 11, 12, 15, 16, 21, 22, 25, and 26 are rejected under 35 U.S.C. 102(e) as being anticipated by Socha, US Patent Application Publication no. 2002/0152452, as cited by the Applicant.

As per claims 1 and 15, Socha discloses a method and a computer program product containing instructions comprising:

- Providing a mask for a mask capable of use in a lithographic process, said mask having a mask function in the spatial frequency domain (**paragraph 65**, use of Fourier Transform), wherein said lithographic process includes the use of a projection system having a defocus amount z along an optical axis, the projection system including pupil optics (**paragraph 101 lines 1-3**);
- Providing a source function having a center spatial frequency coordinate (**page 5 equation 15**);
- Providing a first paraxial pupil function of the pupil optics at a first offset relative to said center spatial frequency coordinate and providing a second paraxial pupil function of the pupil optics at a second offset relative to said center spatial frequency coordinate (**page 9 equation 26**, $K_{\text{sub}0}$ and $K_{\text{sub}0^*}$, derivations of functions taught in equation 20);
- Forming an integrand comprising a product of functions including said source function, said first paraxial pupil function, and said second paraxial pupil function (**integrand in equation 26**);

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- Defining an integration region spanning the intersection of said source function with said first and second paraxial pupil functions, said integration region having a boundary comprising a finite number of arcs (**equation 26**, $\sqrt{\alpha^2 + \beta^2} < \sigma$);
- Integrating said integrand for each of said finite number of arcs to obtain a finite number of contour integrals each corresponding to one of said finite number of arcs, wherein each of said finite number of contour integrals comprises an analytical solution (**page 9 equation 28**);
- Determining a transmission cross-coefficient (TCC) comprising a sum of said finite number of contour integrals (**page 9 equation 29**);
- Simulating an image of said mask in accordance with said lithographic process using said TCC (**paragraph 0067, image intensity**); and
- Using said image to improve said lithographic process (**paragraph 80, improved image formation**).

As per claims 2 and 16,

Socha discloses the first and second paraxial pupil functions each having a phase term that is approximated by a second order Taylor expansion (**page 9 equation 21**).

As per claims 8 and 22,

Socha discloses the projection system having an NA between *about* 0.5 to 0.7 (**paragraph 78 lines 2-5, NA=0.8**).

As per claims 9 and 23,

Socha discloses determining image intensity in accordance with a Hopkins model using the TCC (**paragraph 61**).

As per claims 11 and 25,

Socha discloses determining an aberration pupil function comprising an exponential of a phase term, said phase term expressed by a closed form polynomial series with respect to a deviation $\epsilon_{\text{sub}w}$ from a spherical lens, wherein said exponential is Taylor expanded in terms of said deviation $\epsilon_{\text{sub}w}$ to a specified order, wherein said step of forming an integrand further comprises multiplying each of said first and second paraxial pupil functions by said aberration function (**page 9 equations 23, 24, 26**).

As per claims 12 and 26,

Socha discloses the closed form polynomial series comprising Zernike polynomials (**paragraph 104**).

Claim Rejections - 35 USC § 103

16. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

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17. Claims 3 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over Socha as applied to claims 1, 2, 8, 9, 11, 12, 15, 16, 21, 22, 25, and 26 above, in view of Kintner, "Method for the Calculation of Partially Coherent Imagery," published in Applied Optics Vol. 17 No. 17, September 1978, as cited by the Applicant.

As per claims 3 and 17,

Although Socha discloses circular arcs, the reference does not teach expressly calculating subtended arcs. Kintner teaches computing subtended angles within circles (**page 2751 figure 4**, taught as theta), wherein the angles are relative to the center of the corresponding circle of the arc.

It would have been obvious to one of ordinary skill in the art of mask pattern optimization, at the time of the present invention, to modify Socha's image simulation with Kintner's use of subtended angles. The motivation for doing so would have been to be able to easily calculate the area of the intersection of the two circles in Socha's Figure 1 by computing triangular areas when calculating a transmission cross coefficient (Kintner page 2750 last paragraph-page 2750 first paragraph).

18. Claims 13, 14, 27 and 28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Socha as applied to claims 1, 2, 8, 9, 11, 12, 15, 16, 21, 22, 25, and 26 above, in view of Arnison et al., "A 3D Vectorial Optical Transfer Function Suitable for Arbitrary Pupil Functions," published by Elsevier Science, September 2002.

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As per claims 13 and 27,

Socha does not disclose expressly determining apodization pupil functions. Arnison discloses a method for determining an optical transfer function including determining an apodization pupil function, comprising a factor representing amplitude variations across the pupil (page 6 equation 14), and multiplying the paraxial pupil functions by the apodization pupil function (page 5 equation 12).

It would have been obvious to one of ordinary skill in the art of mask pattern optimization, at the time of the present invention, to modify Socha's image simulation with Arnison's use of apodization pupil functions in order to determine a TCC. The motivation for doing so would have been to be able to maximize performance by being able to achieve higher resolution images (Arnison page 2 paragraph 1 lines 1-5).

As per claims 14 and 28,

Socha discloses the NA being greater than about 0.7 (paragraph 78 lines 2-5, NA=0.8).

Allowable Subject Matter

19. Claims 4-7, 10, 18-21, and 24 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten both in independent form including all of the limitations of the base claim and any intervening claims, and in order to overcome the rejections under 35 USC 112 above.
20. The following is a statement of reasons for the indication of allowable subject matter:

As per claims 4-7 and 18-21:

The best prior art of record regarding these claims is as follows:

- Socha as applied to claims 1, 2, 3, 8, 9, 11, 12, 15, 16, 17, 21, 22, 25, and 26 above
- Kintner as applied to claims 3 and 17 above
- Arnison as applied to claims 13, 14, 27 and 28 above
- Fukuda, US Patent no. 6,329,112

Regarding claims 4 and 18, Socha discloses error terms and the desirability to keep them low, preferably below a predetermined error tolerance (**paragraph 87**), and evaluating over a large finite number of terms in order to reduce error (**paragraphs 86-87**). Kintner, Arnison and Fukuda disclose the calculation and benefits of subtended angles (**Kintner page 2751 figure 4; Arnison page 9 figure 6**, taught as beta; Fukuda **column 5 lines 10-17**). All four documents disclose forming integrands for computing transmission cross coefficients, and Kintner, Arnison and Fukuda disclose parameterizing the integrands in terms of the cosine of the subtended angle. However, none of the teach parameterizing the integrand in terms of a *square root of one plus the cosine of the subtended angle*. There is no obvious motivation to combine the references to achieve or derive such a parameterization; hence the subject matter of the claims is considered allowable.

Claims 5-7 and 19-21 are allowable because of their respective dependences on claims 4 and 18.

As per claims 10 and 24,

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The best prior art of record regarding these claims is as follows:

- Socha as applied to claims 1, 2, 3, 8, 9, 11, 12, 15, 16, 17, 21, 22, 25, and 26 above
- Smith et al., US Patent no. 5,828,455
- Neureuther et al., US Patent no. 7,030,997

Socha discloses the NA being greater than about 0.7 (paragraph 78 lines 2-5, NA=0.8).

Neureuther discloses image intensity being orthogonal to the optical axis (column 9 lines 21-30).

While all three references describe using nonparaxial correction factors (or OPC), the references do not disclose the nonparaxial factor being of the form $(1+NA^{sup.2}g(\{right arrow over (x)\}, z)^{sup.2})$, where $g(x)$ is $g(x \rightarrow, z) = x \rightarrow (NAz)(1 + 942568NA^8z^4)$. There is no obvious motivation to combine the references to achieve or derive such a factor; hence the subject matter of the claims is considered allowable.

Conclusion

21. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

- US Patent no. 6,643,616, issued to Granik et al. on 11/4/2003, discloses using contour integrals in order to improve a lithographic process.

22. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Kimberly Thornewell whose telephone number is (571)272-6543. The examiner can normally be reached on 9am-5:30pm M-F.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kamini Shah can be reached on (571)272-2279. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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